

Amendments to the Drawings:

The attached 2 sheets of drawings include changes to Fig. 2 and changes to Figure 4.

The first sheet, which includes Fig. 2, replaces the original sheet including Fig. 2. In Figure 2, previously omitted spherical cap 125 has been added along with reference number 125.

The second sheet, which includes Fig. 4, replaces the original sheet including Fig. 4. In Figure 4, the reference numbers 124' and 132' have been added.

Attachment: 2 Replacement Sheets

REMARKS/ARGUMENTS

Claims 1-2, 4-8, and 10-40 are resubmitted. Claims 1, 6, 10, 12, 13, 15, 22-24, 27-29, 34, and 39 are currently amended. Claims 3, 9, 41, and 42 are being canceled. No new claims have been added.

Claims 15-22, 24, and 29-33 have been rejected under 35 USC § 112, second paragraph. Claims 1-2, 4-8, and 15-21 have been rejected under 35 USC 102(b) as being anticipated by Ramanujam et al., U.S. Patent 6,323,817 B1 ("Ramanujam"). Claims 23-25 drawn to apparatus and claims 34-38 and 40-42 have been rejected under 35 USC 102(e) as being anticipated by Rao et al., U.S. 2003/0142014 A1 ("Rao"). Claim 3 has been rejected under 35 USC 103(a) as being unpatentable over Ramanujam in view of Reynolds et al., U.S. Patent 5,885,906 ("Reynolds"). Claim 14 has been rejected under 35 USC 103(a) as being unpatentable over Ramanujam in view of Toland et al., U.S. Patent 6,504,514 B1 (Toland). Claim 26 has been rejected under 35 USC 103(a) as being unpatentable over Rao in view of Judasz, U.S. 2002/0190911 A1 (Judasz). Claims 9-13, 27-28, and 39 are objected to but allowable if rewritten to include limitations of the base and any intervening claims and/or to overcome the drawing objections. Claim 22 is objected to but allowable if rewritten to overcome the 35 USC 112 rejections and to include limitations of the base and any intervening claims. Claims 29-33 are objected to but allowable if rewritten to overcome the 35 USC 112 rejections.

Drawings

The drawings have been objected to as not showing every feature specified in claims 3, 9, 12, 27, and 41-42. The Office action states that the features must be shown or canceled from the claims. Claims 3, 9, and 41-42 are canceled without prejudice or disclaimer of the subject matter.

The “spherical cap” in claim 12 is now shown in Figure 2 as spherical cap 125. Spherical cap 125 is described at paragraph [038] of the specification as filed, and paragraph [038] has been modified in regard to spherical cap 125 only by including the new reference number “125”. Therefore the amended Figure 2 conforms the figure to the description already present in the specification as filed, and the amendment to the specification merely supplies a matching reference number to the amended figure. Therefore, Applicants submit that no new matter is being entered.

The “distinct compact 6-port OMT/polarizer” in claim 27 (and claim 28) is now shown in Figure 4 as the distinct OMT/polarizer 132' that a particular horn 124' is connected to. The description in the claims is supported by Figure 4 where each horn 124 - including the particular horn 124' - is clearly connected to a distinct one of the plurality of OMT/polarizers 132, e.g., the particular horn 124' is connected to the distinct OMT/polarizer 132'. The description is also supported in the specification as filed, for example, at paragraph [031] describing each horn as being fed by an OMT/polarizer; paragraph [035] describing an OMT/polarizer assembly behind each horn; and at paragraph [039] describing each OMT/polarizer 132 fitting within available space determined by maximum feed (i.e., horn) size, and matching the number (e.g., 19 horns) of horns 124 to the number (e.g., 19 OMT/polarizers) of OMT/polarizers 132 used. In order that each reference number in the figures occurs in the specification, paragraph [039] has been amended to include a description of OMT/polarizer 132' as the “distinct” one of the OMT/polarizers 132 to which the particular horn 124' is connected. The amendment is made to clarify the usage of “distinct” within what may be regarded as a usual and ordinary usage of the word and as supported by Figure 4 as filed. Therefore, Applicants submit that no new matter is being entered.

Specification

Paragraph **[035]** has been amended to include information not available at the time of filing of the present application regarding a co-pending application incorporated by reference in the present application.

Paragraph **[037]** has been amended as described in the section headed "Rejections under 35 USC § 112".

Paragraphs **[038]** and **[039]** have been amended as described in the section headed "Drawings".

Rejections under 35 USC § 112

Claims 15-22, 24, and 29-33 have been rejected under 35 USC § 112, second paragraph. The Office action asserts that in claims 15 and 29, it is unclear what "oversized" means. "It is unclear because what size, how big is oversized."

Claims 15 and 29 have been amended to clarify "oversized" in comparison to the reflector size claimed in each of claims 15 and 29. The amendment is supported by the specification, for example, at paragraphs **[037]** and **[038]** where the reflector sizing is explained. The reflector aperture is sized based on the lowest frequency band (K-band in the design example provided in the application). The design parameter for the reflector size at K-band is selected based on the beam size and the wavelength at K-band as given by the approximate formula (given in Equation (1)). However, this size of the reflector is generally oversized at higher frequency bands for the same beam size. For example if the reflector is sized at K-band with diameter D, it will be oversized by 50% (1.5 times) at Ka-band of 30 GHz and 222.5% (2.25 times) at EHF band

of 44.5 GHz. Because of this reason, an unshaped parabolic reflector gives beam sizes of 0.5 deg., 0.333 deg., and 0.222 deg. at K, Ka & EHF bands, respectively. By shaping the reflector surface and by using frequency-dependant horn design with displaced phase center locations at the two higher frequency bands relative to the low band, the beam sizes are broadened back to 0.5 deg. at the two high frequency bands. Applicants respectfully submit that this is explained clearly in the application. Thus, it is believed that the comparison of reflector oversizing in reference to the reflector size to form a beam of required size as recited in claims 15 and 29 (as amended) places those claims in condition for allowance.

Claims 16-21 and 30-33 have been rejected because they depend on the rejected base claims 15 and 29 respectively. Therefore, Applicants request that the § 112 rejections to all of claims 15-21 and 29-33 be withdrawn.

The Office action asserts that in claim 22, it is unclear what "half-power beam-width" means. The specification has been amended at paragraph [037] to include a definition of half-power beam width as known and commonly used in the art. The "half-power beam-width" is the diameter of the beam when the power drops -3 dB relative to beam peak power. It is a standard IEEE definition that is understood by antenna designers, and it is also referred to as the "3 dB beam-width". Because the amendment merely adds a standard definition known in the art, Applicants submit that no new matter is added by this amendment to the specification.

In addition, regarding claim 22, the Office action asks "what is meant by 'to produce said required beam size at a K-band frequency taking reflector shaping into account'?" Claim 22 has been amended to read as "to produce said required beam size at a K-band frequency taking the effect of beam broadening at K-band caused by reflector shaping into account" to more closely

reflect the phraseology of the specification as originally filed, for example, at paragraph [037]. In addition, the claim has been amended to replace "reflector shaping" with --having said modified paraboloid shape-- to more clearly refer back to the antecedent previously set by the base claim 15. The statement made in the claim that the reflector is sized "to produce said required beam size at a K-band frequency taking reflector shaping into account" implies that the constant 70 used in Equation (1) is conservative for a parabolic reflector (parabolic reflector uses the constant as 65 due to more focused nature of the beam), but since we are shaping the reflector for higher frequency bands (Ka & EHF) it will impact slightly the K-band beam. Therefore, the constant is increased from 65 to 70 to account for the slight beam broadening effect at K-band frequencies. The specification has been amended at paragraph [037] to clarify that the nature of "taking into account" comprises "adjusting the value of a constant used in an equation for an unshaped paraboloid reflector from 65 to 70". This amendment is merely explanatory in nature and has no end result since Equation (1) remains unchanged, nor is there any change to the invention from the specification as originally filed. Therefore Applicants submit that no new matter is being entered.

In light of the foregoing, Applicants request that the § 112 rejections to claim 22 be withdrawn.

The Office action asserts that in claim 24, "it is unclear a highest frequency band as recited in claim 23 is EHF and Ka band." Claim 23 has been amended to recite an intermediate frequency band. Claim 24 has been amended to recite which of each band is lowest, intermediate, and highest. Thus, it is believed that the § 112 rejections to claim 24 should be withdrawn.

Allowable Subject Matter

Claims 9-13, 27-28, and 39 are objected to but allowable if rewritten to include limitations of the base claim and any intervening claims and/or to overcome the drawing objections.

Claims 10 and 13 are currently amended to include the limitations of the base claim and any intervening claims. Claim 12 is currently amended to include the limitations of the base claim and any intervening claims and to overcome the drawing objections. Claim 11 being dependent on claim 10 (and claim 9 having been canceled), it is thus believed that claims 10-13 are now in condition for allowance. Claims 27-28 are currently amended to include the limitations of the base claim and any intervening claims and to overcome the drawing objections. Claim 39 is currently amended to include the limitations of the base claim and any intervening claims.

Thus, it is believed that all of claims 10-13, 27-28, and 39 are now in condition for allowance.

Claim 22 is objected to but allowable if rewritten to overcome the 35 USC 112 rejections and to include limitations of the base claim and any intervening claims. Claim 22 is currently amended to address the 35 USC 112 rejections and to include the limitations of the base claim and any intervening claims. It is believed that claim 22 is now in condition for allowance.

Claims 29-33 are objected to but allowable if rewritten to overcome the 35 USC 112 rejections. Claim 29 has been amended to address the 35 USC 112 rejections, and claims 30-33 were rejected as depending on a rejected base claim. Thus, it is believed that claims 29-33 are now in condition for allowance.

Ramanujam

Claims 1-2, 4-8, and 15-21 have been rejected under 35 USC 102(b) as being anticipated by Ramanujam et al., U.S. Patent 6,323,817 B1 ("Ramanujam"). Claims 1 and 15 have been amended, support for which can be found in the specification as originally filed, for example, at paragraphs [029] through [031].

The antenna suite disclosed by Ramanujam uses a total of four reflectors to provide multiple spot beams over a single frequency band (Ka). Ramanujam's antenna suite employs two narrow scan antennas using two Gregorian reflectors and two wide scan antennas using two side-fed offset Cassegrain (SFOC) antennas. A total of 8 reflector apertures are needed (4 main reflectors and 4 sub-reflectors) and, thus, teaches away from the multi-band antenna having only a primary reflector and no sub-reflectors for propagating congruent beams over at least three frequency bands as claimed by claims 1 and 15 (as amended). The complex antenna suites of Ramanujam work only at a single frequency band and, additionally, pose mechanical packaging constraints on spacecraft. The present invention as claimed by claims 1 and 15 differs from the teachings of Ramanujam in that the present invention: (1) provides multiple frequency bands, (2) requires only one single reflector to generate all bands and multiple beams, (3) uses multi-band feed horns instead of single band horns, and (4) produces all beams from one reflector aperture rather than inter-leaving among multiple apertures. Therefore, Applicants submit that the 35 USC 102(b) rejections to claims 1 and 15 and the claims dependent from them should be withdrawn.

Rao

Claims 23-25 drawn to apparatus and claims 34-38 and 40-42 have been rejected under 35 USC 102(e) as being anticipated by Rao et al., U.S. 2003/0142014 A1 ("Rao"). Claims 23-24, and 34 have been amended, support for which can be found in the specification as originally filed, for example, at paragraphs [029] through [038].

Rao describes a dual-band antenna system using more efficient feeds and simple reflectors than shown earlier by Toland. Rao employs frequency-dependent horns that have separate phase center locations over the two frequency bands. The system disclosed by Rao is limited compared to the present invention as claimed by claims 23-24, and 34 (as amended) in the sense that Rao's system can not provide congruent multiple spot beams over more than 2 frequency bands and hence is limited to a single satellite service. The present invention as claimed by claims 23-24, and 34 differs from the teachings of Rao in that the feed array of the present invention: (1) can use only a single reflector instead of requiring four reflectors; (2) provides multiple beams over three or more frequency bands; and (3) employs wide-band horns with more than octave bandwidth capability (e.g., K band to EHF band). Therefore, Applicants submit that present invention as claimed by claims 23-24, and 34 (as amended) is not anticipated by Rao and that the rejections under 35 USC 102(e) should be withdrawn.

Reynolds

Claim 3 has been rejected under 35 USC 103(a) as being unpatentable over Ramanujam in view of Reynolds et al., U.S. Patent 5,885,906 ("Reynolds"). Claim 3 has been canceled without prejudice or disclaimer of the subject matter. Nevertheless, Applicants note that Reynolds describes design aspects and construction of large reflectors using unfurlable mesh surfaces for low passive inter-modulation product (PIM) applications. Reynolds teaches design of mesh

surfaces using dielectric fiber with conductive coating in order to reduce PIM and increase RF reflectivity. The range of surface resistivity values that could be used for such a mesh construction at RF frequencies is given. The present application does not teach mesh design, but such surfaces could be made use of at low frequencies for the proposed multi-band antenna system with multiple beams. The reflector disclosed by the present invention is generally a graphite/metallic reflector for high frequencies, but could take the form of mesh reflector (as taught by Reynolds patent) at lower frequency bands.

Toland

Claim 14 has been rejected under 35 USC 103(a) as being unpatentable over Ramanujam in view of Toland et al., U.S. Patent 6,504,514 B1 (Toland). Claim 14 is dependent from claim 1, which is believed to now be in condition for allowance, and thus, claim 14 is believed to be allowable as depending from an allowable claim. Nevertheless, Applicants note that Toland describes a dual-band (K & Ka-bands) antenna system that provides multiple spot beams using four reflector antennas where each reflector antenna takes the form of a side-fed offset Cassegrain (SFOC) antenna, as described previously in Ramanujam's patent. The beams from the four reflectors are inter-leaved on the ground. Each beam is produced by a dual-band corrugated feed, which is inefficient due to thick corrugations. The present invention as claimed by claims 14 differs from the teachings of Toland in that the present invention: (1) supports more than two frequency bands and more than one satellite service; (2) uses a single reflector instead of four reflectors; (3) does not use SFOC reflector system; (4) uses more efficient smooth-walled horns that work at three or more frequency bands. Toland refers to the beamforming network in a sense that it is used to separate and transmit and receive signals from each feed horn, which is different from the present invention in which there is combining of signals from different horns. In contrast, there is no combining of signals from

different horns in Toland's disclosure.

Judasz

Claim 26 has been rejected under 35 USC 103(a) as being unpatentable over Rao in view of Judasz, U.S. 2002/0190911 A1 (Judasz). Claim 26 is dependent from claim 23, which is now believed to be in condition for allowance, and thus, claim 26 is believed to be allowable as depending from an allowable claim. Nevertheless, Applicants note that Judasz discloses what is basically a Potter horn geometry that works at a single frequency band (30 GHz) that suppresses the unwanted TE₁₂ modes. The feed array of Judasz works over a single frequency band only and has narrow bandwidth. The present invention as claimed works over three or more frequency bands with more than an octave bandwidth. Use of such multi-band horns along with a reflector antenna to generate multiple congruent beams over three or more widely separated bands as in the present invention as claimed is not taught or suggested by Judasz.

Prior Art Cited But Not Relied Upon

All of the prior art references cited by the Office action are related to single-band or dual-band antenna systems with either single beam or multiple beams. The present invention as claimed by the amended claims differs significantly from the prior art and is unique in the sense that the present invention teaches an antenna system that is capable of providing multiple overlapping spot beams, each beam congruent over three or more frequency bands that are widely separated. Design details of a tri-band antenna system that operates at K-band (20 GHz), Ka-band (30 GHz) and EHF-band (45 GHz) are disclosed in the present specification. Such a tri-band system allows combining more efficiently the services of two existing satellites - such as EHF

Satcom (works at K-band and EHF-band) and Wideband Gapfiller (works at K-band and Ka-band) - into a single satellite (TSAT /TCA as currently planned by the U.S. Government). In addition, the presently disclosed antenna system requires only one reflector antenna (instead of multiple reflector antennas as used in the prior art) and also utilizes a simple reflector antenna using a single offset reflector (instead of complex dual-reflector antennas used in the prior art).

U.S. Patent 3,569,870 (Foldes)

Foldes addresses a multi-mode feed system applicable for earth station antennas. The multi-mode feed system of Foldes employs a square or rectangular horn where the modes are quite different from those of circular horns. The feed network is complicated and also has a tracking beam. The feed disclosed by Foldes is not suitable for multi-beam antennas such as the present invention's since the feed network size is too large. The present invention differs from Foldes in that the present invention: (1) produces multiple beams instead of single beam; (2) uses a multi-mode circular horn that operates at three or more bands instead of a square horn that operates over no more than two bands.

U.S. Patent 6,366,256 B1 ("Ramanujam '256")

Ramanujam '256 describes an antenna system that generates contiguous spot beams using a side-fed offset Cassegrain (SFOC) antenna. The antenna system requires a complex antenna with a large sub-reflector and a large main reflector, a complex deployment scheme and a low-level beam-forming network. Ramanujam's antenna system works over a single frequency band (30 GHz, Ka-band) and can not support multiple frequency bands as in the present invention. The present invention differs from Ramanujam '256 in that the present invention: (1) supports three or more frequency bands instead

of a single frequency band; (2) supports both uplink and downlink communication signals over multiple bands instead of a single band uplink signal; (3) does not require complex SFOC antenna system; and (4) does not require beam-forming network for at least two frequency bands.

European Patent Application EP 1137102 A2 (Ramanujam EP)


Ramanujam EP utilizes a frequency selective reflector antenna in order to produce identical beams at two frequency bands (K & Ka). The apparatus of Ramanujam EP does not work for more than two frequency bands. It also requires four such complex, frequency selective reflectors to generate multiple beams. The present invention as claimed differs in that the present invention: (1) does not make use of any frequency selective reflector surface; (2) does not require four reflector systems; and (3) works for three or more frequency bands.

CONCLUSION

Applicants would like to thank the Examiner for the notice of allowable subject matter. Reconsideration and withdrawal of the Office Action with respect to claims 1-2, 4-8, and 10-40 is requested. Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

In the event the examiner wishes to discuss any aspect of this response, please contact the attorney at the telephone number identified below.

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